(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 3 341 794 B1

(12) # EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention of the grant of the patent:
02.10.2019 Bulletin 2019/40

(21) Application number: **16751309.2**

(22) Date of filing: **16.08.2016**

(51) Int Cl.:
G03F 7/20 *(2006.01)*

(86) International application number:
PCT/EP2016/069394

(87) International publication number:
WO 2017/036784 (09.03.2017 Gazette 2017/10)

(54) **ILLUMINATION SYSTEM FOR EUV PROJECTION EXPOSURE APPARATUS**

BELEUCHTUNGSSYSTEM FÜR EXTREM-ULTRAVIOLETT(EUV)-PROJEKTIONSBELICHTUNGSANLAGE

SYSTÈME D'ÉCLAIRAGE POUR APPAREIL D'EXPOSITION PAR PROJECTION D'EUV

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR

(30) Priority: **28.08.2015 DE 102015216528**

(43) Date of publication of application:
04.07.2018 Bulletin 2018/27

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Description

[0001] This application claims the benefit of German Patent Application No. DE 10 2015 216 528.0 filed on August 28, 2006.

FIELD OF APPLICATION AND PRIOR ART

[0002] The invention relates to an illumination system for an EUV projection exposure apparatus, an EUV projection exposure apparatus comprising such a illumination system, and a method for operating such an EUV projection exposure apparatus.

[0003] Lithographic projection exposure methods are predominantly used nowadays for producing semiconductor components and other finely structured components, such as, for example, masks for photolithography. In this case, use is made of masks (reticles) or other patterning devices that bear or form the pattern of a structure to be imaged, for example a line pattern of a layer of a semiconductor component. The pattern is positioned in a projection exposure apparatus between an illumination system and a projection lens in the region of the object plane of the projection lens and is illuminated with an illumination radiation shaped by the illumination system. The radiation modified by the pattern travels through the projection lens as projection radiation, said projection lens imaging the pattern with a reduced scale onto the substrate to be exposed. The surface of the substrate is arranged in the image plane of the projection lens optically conjugate to the object plane. The substrate is generally coated with a radiation-sensitive layer (resist, photoresist).

[0004] One of the aims in the development of projection exposure apparatuses is to produce lithographically structures having smaller and smaller dimensions on the substrate. In the case of semiconductor components, for example, smaller structures lead to higher integration densities, which generally has an expedient effect on the performance of the structured components produced. One approach consists in working with shorter wavelengths of the electromagnetic radiation. By way of example, optical systems have been developed which use electromagnetic radiation from the extreme ultraviolet range (EUV) in particular having operating wavelengths in the range of between 5 nanometers (nm) and 30 nm, in particular of 13.5 nm.

[0005] An EUV projection exposure apparatus of the generic type comprising an illumination system of the generic type is known from US 7 473 907 B2. The illumination system is designed for receiving EUV radiation of an EUV radiation source and for shaping illumination radiation from at least one portion of the received EUV radiation. The illumination radiation is directed into an illumination field in an exit plane of the illumination system during exposure operation, wherein the exit plane of the illumination system and the object plane of the projection lens advantageously coincide. The illumination radiation is characterized by specific illumination parameters and is incident on the pattern within the illumination field with a defined shape and size.

[0006] The EUV radiation source, which may be a plasma source, for example, is arranged in a source module separate from the illumination system, said source module generating a secondary radiation source at a source position in an entrance plane of the illumination system.

[0007] The image quality in EUV lithography is determined firstly by the projection lens, secondly also by the illumination system and the EUV radiation source and/or the source module. For a good image quality, a predefined spatial intensity distribution, which should normally be as uniform as possible, should be present for example within the illumination field. Furthermore, a predefined angular distribution should be present. A change in the distribution can be caused both in terms of power and in terms of position by a degradation of the EUV radiation source and/or an alteration of the alignment state of the secondary radiation source in relation to the illumination system.

[0008] For determining the alignment state of the secondary radiation source in relation to the illumination system or optical components of the illumination system, the illumination system comprises an alignment state determining system, e.g. similar or identical to that in US 7 473 907 B2. The alignment state determining system comprises at least one alignment detector configured, during exposure operation, to receive a portion of the EUV radiation emerging from the secondary radiation source and to generate therefrom an alignment detector signal representative of the alignment state of the secondary radiation source.

[0009] Electromagnetic radiation from the EUV range cannot be focused or guided with the aid of refractive optical elements, since the short wavelengths are absorbed by the known optical materials that are transparent at longer wavelengths. Therefore, mirror systems are used in EUV lithography. The illumination system comprises at least one mirror module comprising at least one used mirror element and at least one alignment mirror element. During exposure operation the at least one used mirror element contributes to the shaping of the illumination radiation incident on the illumination field and the at least one alignment mirror element reflects a portion of the EUV radiation of the secondary radiation source directly or indirectly in the direction of the alignment detector.

[0010] The plasma generated in the EUV radiation source comprises ions and electrons that move at high velocity. As a result, despite possible protection measures, contamination of components of the illumination system can occur, e.g. of a mirror surface of a used mirror element. The contamination can adversely influence the image quality. In order to prevent this, for example, it is possible to carry out a cleaning of the contaminated components in the installed state, see e.g. US 7 671 347 B2. Degradations based on other mechanisms are also possible.

PROBLEM AND SOLUTION

[0011] One problem addressed by the present invention is that of providing an illumination system of the generic type for an EUV projection exposure apparatus, with which illumination system it is possible to ensure a minimum image quality using the alignment state determining system despite possible contamination. A further problem addressed by the present invention is that of providing an EUV projection exposure apparatus comprising such an illumination system and a method for operating such an EUV projection exposure apparatus.

[0012] These problems are solved by means of an illumination system having the features of Claim 1, an EUV projection exposure apparatus having the features of Claim 9 and a method according to Claim 11.

[0013] In the illumination system according to the invention, the mirror module is embodied as a structurally exchangeable mirror module. The mirror module can comprise e.g. a common carrier for the at least one used mirror element and the at least one alignment mirror element. The carrier can be fixed on or in a frame structure of the illumination system by means of releasable connections.

[0014] If the mirror module, in particular the at least one used mirror element, is degraded in such a way that the required minimum image quality thus cannot be achieved or can no longer be achieved for a relatively long time, the mirror module can be exchanged for a new mirror module or a mirror module not degraded so severely or can be demounted for cleaning or for maintenance and be reinstalled later. Consequently, it is not necessary for the entire illumination system to be exchanged.

[0015] Furthermore, an optical alignment auxiliary component is assigned to the illumination system according to the invention, wherein with the aid of the optical alignment auxiliary component an alignment auxiliary signal is generatable which allows a checking of the alignment state of the secondary radiation source or of an alignment state of the at least one, in particular new, alignment mirror element after an exchange of the mirror module.

[0016] An optical alignment auxiliary component is a component which is not required for normal exposure operation and which can be used for temporarily checking the alignment state and is coordinated particularly with the requirements in checking the alignment state. The optical alignment auxiliary component operates optically, i.e. using electromagnetic radiation, and can therefore operate without contact.

[0017] The inventors have recognized that the possibility exists that the alignment state of the secondary radiation source in relation to the illumination system can vary during the exchange of a mirror module to be exchanged for a new mirror module. This possibility can be referred to as a first cause. Alternatively or additionally, the possibility exists that the alignment state of the at least one new alignment mirror element of the new mirror module is one that is different relative to an alignment state of the old alignment mirror element of the exchanged mirror module, in particular in relation to the at least one alignment detector, e.g. on account of manufacturing tolerances. By way of example, the mirror surface of the alignment mirror element of the new (exchanged) mirror module may have an orientation and/or surface shape different from those/that of the old alignment mirror element. This possibility can be referred to as a second cause.

[0018] On account of the first and second causes, the respective occurrence and possible extent of which will generally initially be unknown, after an exchange of the mirror module a correct determination of the alignment state of the secondary radiation source in relation to the illumination system by means of the alignment state determining system, in particular by means of the at least one new alignment mirror element, is not readily able to be carried out. This is because the first and second causes may initially be present as mutually inseparable potential causes of a misalignment alternatively or in combination. A reliable reestablishment of the system alignment reference after a mirror module exchange is thus not readily possible.

[0019] By using the optical alignment auxiliary component it is possible simply and rapidly to check whether a misalignment is actually present, to what cause(s) it is traced back and how this can be taken into account during further operation in order to be able to resume exposure operation with defined exposure conditions after a mirror module exchange. Consequently, before the EUV projection exposure apparatus is started up again, the above-described problem of a plurality of unknown possible causes of a misalignment can be reduced to the first or the second cause. The cause that remained is then checkable by means of the alignment state determining system. It is thus possible for the EUV projection exposure apparatus to be started up again simply and rapidly under defined operating conditions.

[0020] During exposure operation, the at least one alignment mirror element can directly or indirectly reflect a portion of the EUV radiation of the secondary radiation source in the direction of the alignment detector. The alignment detector signal representative of the alignment state of the secondary radiation source can serve for determining the alignment state directly or indirectly by means of a comparison with an alignment reference signal for a correct alignment state of the secondary radiation source. Furthermore, the alignment auxiliary signal can be used directly or indirectly by means of a comparison with an alignment auxiliary reference signal, wherein the alignment auxiliary reference signal represents a correct alignment state of the corresponding component for checking the corresponding alignment state.

[0021] Two or more alignment mirror elements can be provided. In particular, the number of alignment mirror elements can be adapted, in particular correspond, to the number of degrees of freedom of the alignment state of the secondary radiation source in relation to the illumination system. Given six degrees of freedom of the alignment state of the secondary radiation source (three translational degrees of freedom and three rotational degrees of freedom) e.g. six alignment mirror elements can thus be present.

[0022] Advantageously, the alignment auxiliary signal may allow not just a checking of the alignment state, but a determination of the alignment state of the secondary radiation source or of an alignment state of the at least one, in particular new, alignment mirror element after an exchange of the mirror module. When determining the alignment state, with the aid of the optical alignment auxiliary component the occurrence and additionally the extent of at least one of the two causes can be checked or the alignment auxiliary signal is representative of the alignment state of the corresponding component.

[0023] The secondary radiation source is the optical interface between the EUV radiation source and the illumination system. It can be a first intermediate image of the EUV radiation source or a further intermediate image following the first intermediate image.

[0024] The EUV projection exposure apparatus comprises the illumination system described above and the source module separate from the illumination system. Furthermore, it comprises an alignment unit signal-connected to the alignment state determining system of the illumination system for aligning the secondary radiation source in relation to the illumination system or optical components of the illumination system depending on the alignment detector signal. The alignment unit allows the secondary radiation source to be brought to the correct alignment state or kept there.

[0025] In the method for operating the EUV projection exposure apparatus mentioned above, in a step (a) the secondary radiation source is switched off. "Switching off" can mean, in particular, that the EUV radiation source can be switched off or shut down and/or masked out by means of a shutter and/or the secondary radiation source can be masked out by means of a shutter. This has the effect that when carrying out a step (b) of exchanging the mirror module, no EUV radiation is incident in the illumination system. The illumination system can then be open to the environment for the work for exchanging the mirror module. An evacuation is only necessary again before EUV radiation is intended to be radiated into the illumination system.

[0026] After the exchange of the mirror module, in a step (c) the secondary radiation source is switched on again in the sense that EUV radiation can emerge again from the secondary radiation source into the illumination system. Moreover, after the exchange of the mirror module, in a step (d) the alignment auxiliary signal is generated by means of the optical alignment auxiliary component. If the EUV radiation of the secondary radiation source is required for step (d), step (d) is not carried out until after step (c). In other cases, step (d) can take place before step (c).

[0027] If the alignment auxiliary signal is generated, in a step (e) the alignment state of the secondary radiation source or the alignment state of the at least one new alignment mirror element is checked by means of the generated alignment auxiliary signal.

[0028] If the secondary radiation source is not necessary for generating the alignment auxiliary signal by means of the optical alignment auxiliary component, this can also be switched on again only after the checking (step (e)), but before operation of the EUV projection exposure apparatus using a result of the checking (step (f)). In this context, "operating" can mean that the EUV projection exposure apparatus may be in exposure operation. In particular, in step (f) the EUV projection exposure apparatus can be operated taking account of the new, possibly changed, alignment state of the secondary radiation source.

[0029] The checking of the alignment state of the secondary radiation source or of the alignment state of the at least one new alignment mirror element by means of the generated alignment auxiliary signal in step (e) can be carried out directly by means of the alignment auxiliary signal or indirectly by means of a comparison with an alignment auxiliary reference signal (indicative of a correct alignment state of the corresponding component). In particular, the alignment auxiliary reference signal can be generated by generating the alignment auxiliary signal by means of the optical alignment auxiliary component before step (b) or even before step (a) and defining said alignment auxiliary signal as alignment auxiliary reference signal.

[0030] In one development of the invention, the illumination system is assigned a positioning device, by means of which the optical alignment auxiliary component outside exposure operation is positionable into a working position in the illumination beam path of the EUV radiation for generating the alignment auxiliary signal. In order to ensure a propagation of the EUV radiation in the illumination beam path, the illumination system generally has a free space that is free of articles obscuring the EUV radiation for the illumination beam path during exposure operation. Said free space can advantageously be used at least partly by the optical alignment auxiliary component outside exposure operation. In particular, the electromagnetic radiation which is used by the optical alignment auxiliary component for checking the alignment state of the secondary radiation source or the alignment state of the at least one alignment mirror element can propagate at least partly along the illumination beam path. Advantageously, the optical alignment auxiliary component can be positionable by means of the positioning device during exposure operation into a storage position outside the illumination beam path of the EUV radiation in particular within a housing of the illumination system or on the latter. In particular, no checking of the alignment state of the secondary radiation source or of the alignment state of the at least one alignment mirror element may then be possible with the aid of the optical alignment auxiliary component.

[0031] At the latest before step (d), in particular before step (b) or even before step (a), in a step (u) the optical alignment auxiliary component outside exposure operation is positioned into the working position in the illumination beam path of the EUV radiation by means of the positioning device for generating the alignment auxiliary signal. After step (d), at the latest before step (f), in a step (y) the optical alignment auxiliary component is removed from the illumination beam path of the EUV radiation, in particular is positioned into the storage position by means of the positioning device.

[0032] The positioning device can comprise a positioning mechanism, such as e.g. a displacement mechanism. In particular, in one configuration of the invention, the positioning device comprises a folding mechanism. The folding mechanism allows a particularly accurately reproducible positioning of the optical auxiliary component in the working position. Moreover, the folding mechanism may allow a space-saving arrangement of the optical auxiliary component in the housing or on the latter. In particular, step (u) and/or step (y) can comprise folding or pivoting the optical alignment auxiliary component into the working position and/or out of the working position.

[0033] In one configuration of the invention, the optical alignment auxiliary component comprises at least one alignment auxiliary mirror configured, in the working position, to reflect directly or indirectly at least one portion of the EUV radiation emerging from the secondary radiation source in the direction of the alignment detector. A detector signal of the alignment detector generated as a result is the alignment auxiliary signal. Consequently, the alignment state of the secondary radiation source can be checked with the aid of the EUV radiation emitted by the latter; that is to say the occurrence of the first cause. Advantageously, the at least one alignment auxiliary mirror in the working position in the illumination beam path can be arranged optically between the secondary radiation source and the mirror module in such a way that it can shade the at least one alignment mirror element. Then no EUV radiation can be incident on the at least one alignment mirror element and/or be reflected from the latter in the direction of the alignment detector, which otherwise might corrupt the checking of the alignment state of the secondary radiation source SLS after the exchange of the mirror module MM. If the positioning device comprises the folding mechanism, the alignment auxiliary mirror can be referred to as a folding mirror. Two or more alignment auxiliary mirrors can be provided. In particular, the number of alignment auxiliary mirrors, like the number of alignment mirror elements, can be adapted, in particular correspond, to the number of degrees of freedom of the alignment state of the secondary radiation source in relation to the illumination system. Given six degrees of freedom of the alignment state of the secondary radiation source (three translational degrees of freedom and three rotational degrees of freedom) six alignment auxiliary mirrors can be present.

[0034] After step (c) in a step (v) at least one portion of the EUV radiation emerging from the secondary radiation source is reflected in the direction of the alignment detector by means of the alignment auxiliary mirror in the working position for generating the alignment auxiliary signal in step (d).

[0035] In one development of the invention, the alignment unit is configured for aligning the secondary radiation source depending on the alignment auxiliary signal if the alignment auxiliary signal is representative of the alignment state of the secondary radiation source. In particular, the method can comprise before step (f) aligning the secondary radiation source depending on the alignment auxiliary signal if the alignment auxiliary signal is representative of the alignment state of the secondary radiation source. Afterwards, if appropriate after step (c) and/or (y), a new alignment reference signal can be generated by generating the alignment detector signal and defining said alignment detector signal as alignment reference signal. In step (f) the EUV projection exposure apparatus can be operated taking account of the new, possibly changed, alignment state of the secondary radiation source.

[0036] In one development of the invention, the optical alignment auxiliary component comprises an alignment auxiliary radiation source configured to generate electromagnetic auxiliary radiation that is directed in the direction of the at least one alignment mirror element, wherein the alignment auxiliary signal is generated from at least one portion of the auxiliary radiation reflected from the alignment mirror element, in particular being representative of the alignment state thereof. Consequently, the alignment state of the at least one alignment mirror element can be checked; that is to say the occurrence of the second cause.

[0037] In a step (w) the auxiliary radiation is generated by means of the alignment auxiliary radiation source, wherein the auxiliary radiation is directed in the direction of the at least one alignment mirror element, wherein in step (d) the alignment auxiliary signal is generated from at least one portion of the auxiliary radiation reflected from the alignment mirror element, in particular being representative of the alignment state thereof.

[0038] If the at least one alignment mirror element is embodied as an alignable alignment mirror element, the method can comprise before step (f) aligning the at least one alignment mirror element into its correct alignment state depending on the alignment auxiliary signal if the alignment auxiliary signal is representative of the alignment state of the alignment mirror element. In particular, the alignment mirror element can be aligned with the illumination system open to the environment. Afterwards, it is possible to continue to use the previous alignment reference signal for a correct alignment state of the secondary radiation source. Alternatively or additionally, the method can comprise before step (f) defining the determined alignment state of the at least one alignment mirror element as the new correct alignment state; in this case the alignment auxiliary signal is representative of the alignment state of the alignment mirror element. The method can then comprise deriving a new alignment reference signal for a correct alignment state of the secondary radiation source from the alignment auxiliary signal.

[0039] In one configuration of the invention, the positioning device is designed to position the alignment auxiliary radiation source in the working position in or near the source position of the secondary radiation source. "Near" can mean that the alignment auxiliary radiation source in the illumination beam path may be spatially nearer the source position than the at least one alignment mirror element. In particular, the alignment auxiliary radiation source can simulate the secondary radiation source in its correct alignment state. Advantageously, step (u) can comprise positioning the alignment auxiliary radiation source near, in particular in, the source position of the secondary radiation source.

[0040] In one configuration of the invention, a wavelength of the electromagnetic auxiliary radiation is in the UV range (between 150 nm and 380 nm), VIS range (between 380 nm and 780 nm) or in the IR range (between 780 nm and 3000 nm). Consequently, the auxiliary radiation experiences little or even no absorption by air, for example if the illumination system is open to the environment for work for exchanging the mirror module and/or for aligning the at least one alignment mirror element. The alignment auxiliary radiation source can comprise in particular a light emitting diode and/or a laser.

[0041] In one configuration of the invention, the illumination system is assigned an alignment auxiliary detector separate from the alignment detector, said alignment auxiliary detector being configured to receive at least one portion of the auxiliary radiation reflected from the at least one alignment mirror element and to generate the alignment auxiliary signal therefrom. In particular, the alignment auxiliary detector may be necessary if the reflected auxiliary radiation is not directed in the direction of the alignment detector and/or the alignment detector is not suitable for receiving the auxiliary radiation. Advantageously, the illumination system can be assigned a further positioning device, by means of which the alignment auxiliary detector outside exposure operation is positionable into a further working position in the illumination beam path of the EUV radiation, preferably directly upstream of the alignment detector, for generating the alignment auxiliary signal.

[0042] In a step (x) at least one portion of the auxiliary radiation reflected from the alignment mirror element is received by means of the alignment auxiliary detector, wherein in step (d) the alignment auxiliary signal is generated from the auxiliary radiation received by the alignment auxiliary detector by means of the alignment auxiliary detector. Advantageously, before step (x), by means of the further positioning device, if present, the alignment auxiliary detector outside exposure operation can be positioned into the further working position in the illumination beam path of the EUV radiation, preferably directly upstream of the alignment detector, for generating the alignment auxiliary signal. After step (d), at the latest before step (f), the alignment auxiliary detector can then be removed from the illumination beam path of the EUV radiation, in particular by means of the further positioning device, into a further storage position.

[0043] In one development of the invention, the at least one used mirror element optically directly follows the entrance plane in the illumination beam path. Consequently, the at least one used mirror element can be contaminated to a particularly great extent. In particular, the at least one used mirror element can comprise a field facet mirror or be a field facet mirror.

BRIEF DESCRIPTION OF THE DRAWINGS

[0044] Further advantages and aspects of the invention are evident from the claims and from the following description of preferred embodiments of the invention which are explained below with reference to the figures. Here in the figures:

Figure 1 shows a schematic illustration of an EUV projection exposure apparatus comprising an illumination system with an optical alignment auxiliary component in a storage position in accordance with one embodiment of the invention;

Figure 2 shows the EUV projection exposure apparatus from Figure 1 with the optical alignment auxiliary component in a working position;

Figure 3 shows a method for operating the EUV projection exposure apparatus from Figure 1;

Figure 4 shows a schematic illustration of an EUV projection exposure apparatus with a further embodiment of an illumination system according to the invention with an optical alignment auxiliary component in a working position; and

Figure 5 shows a method for operating the EUV projection exposure apparatus from Figure 4.

DETAILED DESCRIPTION OF THE EXEMPLARY EMBODIMENTS

[0045] An EUV projection exposure apparatus WSC in Figures 1 and 2 comprises an illumination system ILL, a source module SM separate from the illumination system ILL, and a projection lens PO. The source module SM generates a secondary radiation source SLS at least during exposure operation as shown in Figure 1, at a source position SP in an entrance plane IS of the illumination system ILL. In detail, the source module SM comprises a housing SMH and, arranged therein, an EUV radiation source LS in the form of a plasma source, a collector CO, a diffraction grating GE and an EUV-transmissive membrane DIA ("spectral purity filter"). The EUV radiation source LS is designed for generating EUV radiation LR, as indicated by dotted lines in Figures 1 and 2. The collector CO and the diffraction grating GE are designed to image the EUV radiation LR or the EUV radiation source LS into an intermediate image, the secondary radiation source SLS, in the entrance plane IS of the illumination system ILL in a first order of diffraction. The secondary radiation source SLS is the optical interface between the EUV radiation source or the source module SM and the illumination system ILL.

[0046] The illumination system ILL is designed for receiving the EUV radiation LR of the EUV radiation source LS and for shaping illumination radiation ILR from at least one portion of the received EUV radiation LR. In detail, the illumination system ILL comprises a housing ILH and, arranged therein, a mirror module MM, a so-called pupil facet mirror PFM and a grazing incidence mirror GIM. The mirror module MM comprises at least one used mirror element UM, in the embodiment a plurality thereof, which form a field facet mirror. During exposure operation, the used mirror elements UM, the pupil facet mirror PFM and the grazing incidence mirror GIM contribute to the shaping of the illumination radiation ILR incident on the illumination field.

[0047] During exposure operation, as shown in Figure 1, the illumination radiation ILR is directed into an illumination field in an exit plane ES of the illumination system ILL, wherein the exit plane ES of the illumination system and an object plane of the projection lens PO coincide. The illumination radiation ILR is characterized by specific illumination parameters and is incident within the illumination field with a defined shape and size on a mask or a patterning device MA, which is positioned optically between the illumination system ILL and the projection lens PO in the region of the exit plane ES or the object plane. The mask or the patterning device MA bears or forms the pattern of a structure to be imaged. The radiation altered by the pattern passes as projection radiation PR through the projection lens PO, which images the pattern on a reduced scale onto a substrate WAF to be exposed. A surface of the substrate WAF is arranged in the image plane IP of the projection lens PO, said image plane being optically conjugate with respect to the object plane of the projection lens PO, wherein at least the surface of the substrate WAF will generally be coated with a radiation-sensitive layer.

[0048] For a good image quality in EUV lithography or the EUV projection exposure apparatus WSC, a predefined spatial intensity distribution and a predefined angular distribution should be present within the illumination field. A change in the distribution can be brought about both in terms of power and in terms of position by a degradation of the EUV radiation source LS and/or a variation of the alignment state of the secondary radiation source SLS in relation to the illumination system ILL.

[0049] For determining the alignment state of the secondary radiation source SLS in relation to the illumination system ILL or the optical components thereof, the illumination system ILL comprises an alignment state determining system ADS. The alignment state determining system ADS comprises at least one alignment detector AD which is arranged adjacent to or adjoining the pupil facet mirror PFM. Furthermore, the mirror module MM comprises at least one alignment mirror element AM, in the embodiment two thereof. During exposure operation, as shown in Figure 1, the at least one alignment mirror element AM reflects a portion of the EUV radiation LR of the secondary radiation source SLS directly in the direction of the alignment detector AD. The latter is configured to receive a portion of the EUV radiation LR emerging from the secondary radiation source SLS and to generate therefrom an alignment detector signal AS representative of the alignment state of the secondary radiation source SLS. The alignment state determining system ADS furthermore comprises a control unit CU signal-connected to the alignment detector AD, as indicated by dashed lines in Figures 1 and 2. The control unit CU is designed to compare the alignment detector signal AS with an alignment reference signal for a correct alignment state of the secondary radiation source SLS and thereby to determine the alignment state of the secondary radiation source SLS.

[0050] The EUV projection exposure apparatus WSC comprises an alignment unit AU signal-connected to the alignment state determining system ADS of the illumination system ILL for aligning the secondary radiation source SLS in relation to the illumination system ILL depending on the alignment detector signal AS or on the comparison thereof with the alignment reference signal. The alignment unit AU allows the secondary radiation source SLS to be brought to the correct alignment state or kept there. In detail, the alignment unit AU is designed to rotate and/or to displace in each case the EUV radiation source LS, the diffraction grating GE and the housing SMH of the source module SM, as indicated by the arrow groups P1, P2 and P3.

[0051] An illumination system and respectively an EUV projection exposure apparatus having a similar construction and a similar functioning are known from US 7 473 907 B2. In particular, reference is made to Figures 1a, 2a to 2d, 3a to 3g, 4 and 5 in US 7 473 907 B2 together with the associated description.

[0052] The EUV radiation source LS can cause a constant contamination of components of the illumination system ILL, despite the membrane DIA acting as a filter, in particular of a mirror surface of the at least one used mirror element UM which directly follows the entrance plane IS in the illumination beam path OP. The contamination can adversely influence the image quality of the EUV projection exposure apparatus WSC.

[0053] The mirror module MM is embodied as a structurally exchangeable mirror module MM. The mirror module MM is fixed on or in a frame structure FR of the illumination system ILL by means of releasable connections. Furthermore, the housing ILH of the illumination system ILL has a maintenance flap DO. If the mirror module MM, in particular the at least one used mirror element UM, is degraded in such a way that a required minimum image quality thus cannot be achieved or can no longer be achieved for a relatively long time, the mirror module can be exchanged for a new mirror module, or mirror module not degraded so severely, through the maintenance flap DO, which is opened for this purpose, or can be demounted for cleaning or for maintenance and be reinstalled later.

[0054] During the exchange of the mirror module for a new mirror module, the alignment state of the secondary radiation source SLS in relation to the illumination system ILL may vary; which is referred to here as a possible first cause. Alternatively or additionally, an alignment state of the at least one new alignment mirror element of the new mirror module may be one that is different relative to an alignment state of the old alignment mirror element of the exchanged mirror module, in particular in relation to the at least one alignment detector AD; which is referred to here as a possible second cause. On account of the first cause and/or the second cause, after an exchange of the mirror module MM a correct determination of the alignment state of the secondary radiation source SLS in relation to the illumination system ILL by means of the alignment state determining system ADS, in particular by means of the at least one new alignment mirror element AM, is not readily able to be carried out.

[0055] An optical alignment auxiliary component AAC is assigned to the illumination system ILL, wherein with the aid of the optical alignment auxiliary component AAC an alignment auxiliary signal AAS is generatable which allows a checking, in particular a determination, of the alignment state of the secondary radiation source SLS after an exchange of the mirror module MM; the occurrence of the first cause. The optical alignment auxiliary component AAC operates optically, i.e. using electromagnetic radiation. The alignment auxiliary signal AAS serves for checking or determining the alignment state of the secondary radiation source SLS by means of a comparison with an alignment auxiliary reference signal, wherein the alignment auxiliary reference signal represents a correct alignment state of the secondary radiation source SLS.

[0056] In detail, the optical alignment auxiliary component AAC comprises at least one alignment auxiliary mirror AAM; there are exactly two in the embodiment. The illumination system ILL is assigned a positioning device PD comprising a folding mechanism FM, by means of which the at least one alignment auxiliary mirror AAM is positionable or foldable between a storage position shown in Figure 1 outside the illumination beam path OP of the EUV radiation LR and a working position shown in Figure 2 in the illumination beam path OP for generating the alignment auxiliary signal AAS. The alignment auxiliary mirror AAM can be referred to as a folding mirror.

[0057] The at least one alignment auxiliary mirror AAM is configured, in the working position, to reflect at least one portion of the EUV radiation LR emerging from the secondary radiation source SLS in the direction of the alignment detector AD. In particular, in this case EUV radiation used by the at least one alignment auxiliary mirror AAM for checking the alignment state of the secondary radiation source SLS propagates at least partly along the illumination beam path OP. A detector signal AS of the alignment detector AD generated as a result is the alignment auxiliary signal AAS. Consequently, the alignment state of the secondary radiation source SLS can be checked or determined.

[0058] In the working position, the at least one alignment auxiliary mirror AAM in the illumination beam path OP is arranged optically between the secondary radiation source SLS and the mirror module MM in such a way that it can shade the at least one alignment mirror element AM. As a result, no EUV radiation LR can be incident on the at least one alignment mirror element AM and/or be reflected from the latter in the direction of the alignment detector AD, which otherwise might corrupt the checking or the determination of the alignment state of the secondary radiation source SLS after the exchange of the mirror module MM.

[0059] The control unit CU is designed to compare the alignment auxiliary signal AAS with the alignment auxiliary reference signal and thereby to determine the alignment state of the secondary radiation source SLS. The alignment unit AU is configured for aligning the secondary radiation source SLS depending on the alignment auxiliary signal AAS or on the comparison thereof with the alignment auxiliary reference signal.

[0060] In a method for operating the EUV projection exposure apparatus WSC described above, outside exposure operation in a step (u) the at least one alignment auxiliary mirror AAM is positioned or folded into the working position from the storage position by means of the positioning device PD comprising the folding mechanism FM, as shown in Figure 3. Afterwards, in a step (v) at least one portion of the EUV radiation LR emerging from the secondary radiation source SLS is reflected in the direction of the alignment detector AD by means of the at least one alignment or auxiliary mirror AAM for generating the alignment auxiliary signal AAS by means of the alignment detector AD in a step (d). The alignment detector AD receives the portion of the EUV radiation LR emerging from the secondary radiation source SLS and generates the alignment auxiliary signal AAS therefrom. At this point in time the alignment state of the secondary radiation source SLS is generally correct and said alignment auxiliary signal AAS is defined as a new alignment auxiliary reference signal, in particular in the control unit CU, in a step (s).

[0061] Afterwards, in a step (a) the secondary radiation source SLS or the EUV radiation source LS is switched off. The illumination system ILL is then opened to the environment for work for exchanging the mirror module MM in a step (b), in particular by means of the opening of the maintenance flap DO. After the exchange of the mirror module MM, the illumination system ILL is closed, in particular by means of the closing of the maintenance flap DO. Afterwards, the illumination system ILL or the projection exposure apparatus WSC is evacuated and in a step (c) the secondary radiation source SLS or the EUV radiation source LS is switched on again in the sense that EUV radiation LR can emerge again from the secondary radiation source SLS into the illumination system ILL.

[0062] After the exchange of the mirror module MM, steps (v) and (d) are repeated. If the alignment auxiliary signal AAS is generated, in a step (e) the alignment state of the secondary radiation source SLS is checked or determined. The checking or the determination of the alignment state of the secondary radiation source SLS by means of the generated alignment auxiliary signal AAS is effected by means of a comparison with the previously defined alignment auxiliary reference signal by the control unit CU. In a step (r), the secondary radiation source SLS is aligned, if necessary, in its correct alignment state depending on the alignment auxiliary signal AAS or on the comparison thereof with the alignment auxiliary reference signal by means of the alignment unit AU.

[0063] In a step (y) the at least one alignment auxiliary mirror AAM is removed from the illumination beam path OP of the EUV radiation LR or is positioned or folded from the working position into the storage position by means of the positioning device PD comprising the folding mechanism FM. A portion of the EUV radiation LR emerging from the secondary radiation source SLS is then reflected in the direction of the alignment detector AD by means of the at least one alignment mirror element AM for generating the alignment detector signal AS by means of the alignment detector AD. The alignment detector AD receives the portion of the EUV radiation LR emerging from the secondary radiation source SLS and generates the alignment detector signal AS therefrom. At this point in time the alignment state of the secondary radiation source is correct and said alignment detector signal AS is defined as a new alignment reference signal, in particular in the control unit CU, in a step (s').

[0064] The EUV projection exposure apparatus WSC can then be operated again in a step (f); in particular, the EUV projection exposure apparatus WSC can be in exposure operation.

[0065] Figure 4 shows a further illumination system ILL as a variant of the illumination system ILL of the EUV projection exposure apparatus WSC in Figures 1 and 2, wherein to facilitate understanding not only identical but also functionally equivalent elements are provided with the same reference signs as in the embodiment explained above, to the description of which reference is made in this respect.

[0066] In contrast to the illumination system ILL in Figures 1 and 2, the illumination system ILL in Figure 4 is assigned an optical alignment auxiliary component AAC, wherein with the aid of the optical alignment auxiliary component AAC an alignment auxiliary signal AAS' is generatable which allows a checking, in particular a determination, of the alignment state of the at least one, in particular new, alignment mirror element AM after an exchange of the mirror module MM; the occurrence of the second cause. The alignment auxiliary signal AAS' serves for checking or determining the alignment state of the at least one alignment mirror element AM by means of a comparison with an alignment auxiliary reference signal, wherein the alignment auxiliary reference signal represents a correct alignment state of the at least one alignment mirror element AM.

[0067] In detail, the optical alignment auxiliary component AAC comprises at least one alignment auxiliary radiation source ALS. The illumination system ILL is assigned a positioning device PD' comprising a folding mechanism FM', by means of which the alignment auxiliary radiation source ALS is positionable or foldable between a storage position (not shown here) outside the illumination beam path OP of the EUV radiation LR and a working position shown in Figure 4 in the illumination beam path OP for generating the alignment auxiliary signal AAS'. The positioning device PD' is designed to position the alignment auxiliary radiation source ALS near, in particular in, the source position SP of the secondary radiation source SLS in the entrance plane IS of the illumination system ILL between the housing ILH thereof and the housing SMH of the source module SM.

[0068] The alignment auxiliary radiation source ALS is configured to generate electromagnetic auxiliary radiation ALR that is directed in the direction of the at least one alignment mirror element AM, in particular in the working position wherein the alignment auxiliary signal AAS' is generated from at least one portion of the auxiliary radiation ALR reflected from the alignment mirror element AM, in particular being representative of the alignment state thereof. In particular, in this case the auxiliary radiation ALR used by the alignment auxiliary radiation source ALS for checking the alignment state of the at least one alignment mirror element AM propagates at least partly along the illumination beam path OP, as indicated by dotted lines in Figure 4. In particular, the alignment auxiliary radiation source can simulate the secondary radiation source in its correct alignment state. A wavelength of the electromagnetic auxiliary radiation ALR is in the UV range, VIS range or in the IR range and thus experiences little or even no absorption by air, for example if the illumination system ILL is open to the environment for work for exchanging the mirror module MM and/or for aligning the at least one alignment mirror element AM, if possible.

[0069] Furthermore, the illumination system ILL is assigned an alignment auxiliary detector AAD separate from the alignment detector AD. Moreover, the illumination system ILL is assigned a further positioning device PD" comprising a further folding mechanism FM", by means of which the alignment auxiliary detector AAD is positionable or foldable between a further storage position (not shown here) outside the illumination beam path OP of the EUV radiation LR and a further working position shown in Figure 4 in the illumination beam path OP directly upstream of the alignment detector AD for generating the alignment auxiliary signal AAS'. The alignment auxiliary detector AAD is configured to receive at least one portion of the auxiliary radiation ALR reflected from the at least one alignment mirror element AM and to generate the alignment auxiliary signal AAS' therefrom. The alignment auxiliary detector AAD is signal-connected to the control unit CU. Consequently, the alignment state of the at least one alignment mirror element AM can be checked or determined.

[0070] The at least one alignment mirror element AM is embodied as an alignable alignment mirror element AM. That means that the alignment mirror element AM is embodied such that it is variably positionable and/or orientable, in particular by its mirror surface, in relation to the alignment detector AD or the frame structure FR or the housing ILH of the illumination system ILL. The control unit CU is designed to compare the alignment auxiliary signal AAS' with the alignment auxiliary reference signal and thereby to determine the alignment state of the at least one alignment mirror element AM. Depending on the alignment auxiliary signal AAS' or on the comparison thereof with the alignment auxiliary reference signal, the at least one alignment mirror element AM can be aligned in its correct alignment state, e.g. by the engineer with the illumination system ILL open to the environment. It is then possible to continue to use the previous alignment reference signal for a correct alignment state of the secondary radiation source.

[0071] As an alternative or in addition to the embodiment of the at least one alignment mirror element AM as an alignable alignment mirror element AM and the corresponding embodiment of the control unit CU, the determined alignment state of the at least one, in particular new, alignment mirror element AM can be defined as a new correct alignment state after an exchange of the mirror module MM. The control unit CU can then be designed to derive a new alignment reference signal for a correct alignment state of the secondary radiation source SLS from the alignment auxiliary signal AAS' or from a comparison thereof with the alignment auxiliary reference signal.

[0072] In a method for operating the above-described EUV projection exposure apparatus WSC in Figure 4, outside exposure operation in a step (a) the secondary radiation source SLS or the EUV radiation source LS is switched off, as shown in Figure 5. Afterwards, in a step (u) the alignment auxiliary radiation source ALS is positioned from the storage position into the working position by means of the positioning device PD' comprising the folding mechanism FM' by folding over, and the alignment auxiliary detector ADD is positioned or folded from the further storage position into the further working position by means of the further positioning device PD" comprising the further folding mechanism FM". For this purpose, the illumination system ILL can be opened to the environment, in particular by means of the opening of the maintenance flap DO. Afterwards, in a step (w) the alignment auxiliary radiation source ALS generates the auxiliary radiation ALR, wherein the latter is directed in the direction of the at least one alignment mirror element AM. In a step (x) the alignment auxiliary detector AAD receives at least one portion of the auxiliary radiation ALR reflected from the alignment mirror element AM and generates the alignment auxiliary signal AAS' therefrom in a step (d). At this point in time the alignment state of the at least one alignment mirror element AM is generally correct and said alignment auxiliary signal AAS' is defined as a new alignment auxiliary reference signal, in particular in the control unit CU, in a step (s").

[0073] Then at the latest, the illumination system ILL is opened to the environment for work for exchanging the mirror module MM in a step (b). After the exchange of the mirror module MM, steps (w), (x) and (d) are repeated. If the alignment auxiliary signal AAS' is generated, in a step (e) the alignment state of the at least one alignment mirror element AM is checked or determined. The checking or the determination of the alignment state of the at least one alignment mirror element AM by means of the generated alignment auxiliary signal AAS' is effected by means of a comparison with the previously defined alignment auxiliary reference signal by the control unit CU.

[0074] In a step (r') the at least one alignment mirror element AM is aligned, if necessary, in its correct alignment state depending on the alignment auxiliary signal AAS' or on the comparison thereof with the alignment auxiliary reference signal e.g. by the engineer with the illumination system ILL open to the environment. It is then possible to continue to use the previous alignment reference signal for a correct alignment state of the secondary radiation source SLS in a later step (f), operating the EUV projection exposure apparatus WSC.

[0075] Alternatively or additionally, in step (r') the determined alignment state of the at least one alignment mirror element AM can be defined as a new correct alignment state and the control unit CU can derive, if necessary, from the alignment auxiliary signal AAS' or from a comparison thereof with the alignment auxiliary reference signal, a new alignment reference signal for a correct alignment state of the secondary radiation source SLS for later operation of the EUV projection exposure apparatus WSC (step (f)).

[0076] Afterwards, in a step (y) the alignment auxiliary radiation source ALS is removed from the illumination beam path OP of the EUV radiation LR or is positioned or folded from the working position into the storage position by means of the positioning device PD' comprising the folding mechanism FM', and the alignment auxiliary detector AAD is removed from the illumination beam path

OP of the EUV radiation LR or is positioned or folded from the further working position into the further storage position by means of the positioning device PD" comprising the folding mechanism FM". For this purpose, the illumination system ILL can still be open to the environment.

[0077] Then at the latest, the illumination system ILL is closed, in particular by means of the closing of the maintenance flap DO. Afterwards, the illumination system ILL or the projection exposure apparatus WSC is evacuated and in a step (c) the secondary radiation source SLS or the EUV radiation source LS is switched on again in the sense that EUV radiation LR can again emerge from the secondary radiation source SLS in the illumination system ILL. A portion of the EUV radiation LR emitting from the secondary radiation source SLS is then reflected in the direction of the alignment detector AD by means of the at least one alignment mirror element AM for generating the alignment detector signal AS by means of the alignment detector AD. The alignment detector AD receives the portion of the EUV radiation LR emerging from the secondary radiation source SLS and generates the alignment detector signal AS therefrom.

[0078] At this point in time the alignment state of the at least one alignable alignment mirror element AM is correct and an alignment reference signal for a correct alignment state of the secondary radiation source SLS is defined, in particular in the control unit CU. The alignment state of the secondary radiation source SLS can thus be determined. The determination of the alignment state of the secondary radiation source SLS by means of the generated alignment detector signal AS is effected by means of a comparison with the alignment reference signal by the control unit CU. The secondary radiation source SLS is aligned, if necessary, in its correct alignment state depending on the alignment detector signal AS or on the comparison thereof with the alignment reference signal by the alignment unit AU.

[0079] The EUV projection exposure apparatus WSC can then be operated again in a step (f); in particular, the EUV projection exposure apparatus WSC can be in exposure operation.

[0080] The illumination systems shown can comprise a number of cleaning devices (not shown here) e.g. in the form of hydrogen sources and associated hot filaments for cleaning the mirrors. In particular, a use duration of the mirror module until the latter is exchanged can be lengthened as a result.

[0081] In the embodiments shown, the illumination system comprises three mirrors that contribute to the shaping of the illumination radiation. Alternatively, the illumination system can comprise fewer or more than three mirrors that can contribute to the shaping of the illumination radiation. Furthermore, the mirror module comprises at least one used mirror element that forms a field facet mirror. Alternatively, the at least one used mirror element can perform a different task from forming the field facet mirror. Moreover, the alignment detector is arranged adjoining the pupil facet mirror. Alternatively, in particular in a manner adapted to the task of the at least one used mirror element, the alignment detector can be arranged elsewhere.

[0082] During exposure operation the at least one alignment mirror element reflects a portion of the EUV radiation of the secondary radiation source directly in the direction of the alignment detector. In an alternative embodiment, the at least one alignment mirror element can reflect a portion of the EUV radiation of the secondary radiation source indirectly in the direction of the alignment detector. Furthermore, the at least one alignment auxiliary mirror reflects at least one portion of the EUV radiation emerging from the secondary radiation source directly in the direction of the alignment detector. In an alternative embodiment, the at least one alignment auxiliary mirror can reflect at least one portion of the EUV radiation of the secondary radiation source indirectly in the direction of the alignment detector.

[0083] In the embodiments shown, the mirror module has exactly two alignment mirror elements. In alternative embodiments, a single alignment mirror element can suffice or more than two alignment mirror elements can be present, e.g. three, four, five or six. The same correspondingly applies to the number of alignment auxiliary mirrors of the optical alignment auxiliary component. Instead of the two alignment auxiliary mirrors shown, a single one can suffice. It is also possible for more than two alignment auxiliary mirrors to be present, e.g. three, four, five or six.

[0084] In the embodiments shown, the alignment detector signal serves for determining the alignment state of the secondary radiation source by means of a comparison thereof with the alignment reference signal and the alignment auxiliary signal serves for determining the alignment state of the secondary radiation source or of the at least one alignment mirror element by means of a comparison thereof with the alignment auxiliary reference signal. Alternatively, the alignment detector signal can serve directly for determining the alignment state of the secondary radiation source and/or the alignment auxiliary signal can serve directly for determining the alignment state of the secondary radiation source or of the at least one alignment mirror element. The alignment reference signal and/or the alignment auxiliary reference signal then need not be generated or defined. Furthermore, it can suffice if the alignment auxiliary signal allows only a checking of the alignment state of the secondary radiation source or of the at least one alignment mirror element.

[0085] In one of the embodiments shown, the alignment auxiliary detector separate from the alignment detector receives the auxiliary radiation and generates the alignment auxiliary signal therefrom. Alternatively, the alignment detector can be designed for receiving the auxiliary radiation and generating the alignment auxiliary signal therefrom. An alignment auxiliary detector can then be dispensed with. Furthermore, the auxiliary radiation source is arranged in the illumination beam path in the working position. Alternatively, the auxiliary radiation source can be arranged permanently outside the illumination beam path. Correspondingly, the alignment auxiliary detector can be arranged outside the illumination beam path. If appropriate, a positioning device and/or a further positioning device can then be dispensed with. Moreover, in the embodiments shown, the positioning device and/or the further positioning device respectively comprise(s) a folding mechanism. Alternatively, the positioning device and/or the further positioning device can comprise a different positioning mechanism, such as e.g. a displacement mechanism.

[0086] Moreover, in the embodiments shown, the alignment unit is designed to rotate and/or to displace in each case the EUV radiation source, the diffraction grating and the housing of the source module. Alternatively, the alignment unit can be designed to rotate and/or to displace only one or two of the components mentioned or different components from those mentioned.

Claims

1. Illumination system (ILL) for an EUV projection exposure apparatus (WSC) for receiving EUV radiation (LR) of an EUV radiation source (LS) and for shaping illumination radiation (ILR) from at least one portion of the received EUV radiation, wherein the illumination radiation is directed into an illumination field in an exit plane (ES) of the illumination system during exposure operation,
wherein the EUV radiation source is arranged in a source module (SM) separate from the illumination system, said source module generating a secondary radiation source (SLS) at a source position (SP) in an entrance plane (IS) of the illumination system, comprising:

    an alignment state determining system (ADS) for determining an alignment state of the secondary radiation source in relation to the illumination system, wherein the alignment state determining system comprises an alignment detector (AD) configured to receive a portion of the EUV radiation emerging from the secondary radiation source and to generate therefrom an alignment detector signal (AS) representative of the alignment state, and
    a mirror module (MM) comprising a used mirror element (UM) and an alignment mirror element (AM), wherein during exposure operation the used mirror element contributes to the shaping of the illumination radiation incident on the illumination field and the alignment mirror element reflects a portion of the EUV radiation of the secondary radiation source in the direction of the alignment detector,

    characterized in that
    the mirror module (MM) is embodied as a structurally exchangeable mirror module, and
    an optical alignment auxiliary component (AAC) is assigned to the illumination system (ILL), wherein with the aid of the optical alignment auxiliary component an alignment auxiliary signal (AAS, AAS') is generatable which allows a checking of the alignment state of the secondary radiation source (SLS) or of an alignment state of an alignment mirror element (AM) after an exchange of the mirror module.

2. Illumination system (ILL) according to Claim 1, **characterized in that** the illumination system is assigned a positioning device (PD, PD'), by means of which the optical alignment auxiliary component (AAC) outside exposure operation is positionable into a working position in the illumination beam path (OP) of the EUV radiation (LR) for generating the alignment auxiliary signal (AAS, AAS') wherein preferably the positioning device (PD, PD', PD") comprises a folding mechanism (FM, FM').

3. Illumination system (ILL) according to Claim 2, **characterized in that** the optical alignment auxiliary component (AAC) comprises an alignment auxiliary mirror (AAM) configured, in the working position, to reflect a portion of the EUV radiation (LR) emerging from the secondary radiation source (SLS) in the direction of the alignment detector (AD), wherein preferably the illumination system (ILL) is assigned a positioning device (PD) comprising a folding mechanism (FM), by means of which the at least one alignment auxiliary mirror (AAM) is foldable between a storage position outside the illumination beam path (OP) of the EUV radiation (LR) and a working position in the illumination beam path (OP) for generating the alignment auxiliary signal (AAS).

4. Illumination system (ILL) according to Claim 3, **characterized in that** the at least one alignment auxiliary mirror (AAM) in the working position in the illumination beam path is arranged optically between the secondary radiation source (SLS) and the mirror module in such a way that it can shade the at least one alignment mirror element.

5. Illumination system (ILL) according to Claim 3 or 4, **characterized in that** the illumination system (ILL) comprises exactly two alignment auxiliary mirrors and/or **in that** the number of alignment mirror elements (AAM) corresponds to the number of degrees of freedom of the alignment state of the secondary radiation source (SLS) in relation to the illumination system (ILL).

6. Illumination system (ILL) according to any of Claims

1 to 5, **characterized in that** the optical alignment auxiliary component (AAC) comprises an alignment auxiliary radiation source (ALS) configured to generate auxiliary radiation (ALR) that is directed in the direction of the alignment mirror element (AM), wherein the alignment auxiliary signal (AAS') is generated from a portion of the auxiliary radiation reflected from the alignment mirror element, wherein preferably the positioning device (PD') is designed to position the alignment auxiliary radiation source (ALS) in the working position in or near the source position (SP) of the secondary radiation source (SLS) and/or a wavelength of the auxiliary radiation (ALR) is in the UV range, VIS range or in the IR range.

7. Illumination system (ILL) according to Claim 6, **characterized in that** the illumination system is assigned an alignment auxiliary detector (AAD) separate from the alignment detector (AD), said alignment auxiliary detector being configured to receive a portion of the auxiliary radiation (ALR) reflected from the alignment mirror element (AM) and to generate the alignment auxiliary signal (AAS') therefrom.

8. Illumination system (ILL) according to any of Claims 1 to 7, **characterized in that** the used mirror element (UM) directly follows the entrance plane (IS) in the illumination beam path (OP).

9. EUV-projection exposure apparatus (WSC) comprising:

- an illumination system (ILL) according to any of Claims 1 to 8,
- a source module (SM) separate from the illumination system with an EUV radiation source (LS) for generating EUV radiation (LR) wherein the source module generates a secondary radiation source (SLS) at a source position (SP) in an entrance plane (IS) of the illumination system, and
- an alignment unit (AU) signal-connected to the alignment state determining system (ADS) of the illumination system for aligning the secondary radiation source in relation to the illumination system depending on the alignment detector signal (AS).

10. EUV projection exposure apparatus (WSC) according to Claim 9, **characterized in that** the alignment unit (AU) is configured for aligning the secondary radiation source (SLS) depending on the alignment auxiliary signal (AAS) if the alignment auxiliary signal is representative of the alignment state of the secondary radiation source.

11. Method for operating an EUV projection exposure apparatus (WSC) according to Claim 9 or 10, **characterized by** the following steps:

(a) switching off the secondary radiation source (SLS),
(b) exchanging the mirror module (MM),
(c) switching on the secondary radiation source,
(d) generating an alignment auxiliary signal (AAS, AAS') by means of the optical alignment auxiliary component (AAC),
(e) checking the alignment state of the secondary radiation source or an alignment state of an alignment mirror element (AM) after an exchange of the mirror module by means of the generated alignment auxiliary signal, and
(f) operating the EUV projection exposure apparatus using a result of the checking.

12. Method according to Claim 11, wherein the positioning device (P) is assigned to the illumination system (ILL), **characterized by** the following steps:

(u) positioning the optical alignment auxiliary component (AAC) outside exposure operation into a working position in the illumination beam path (OP) of the EUV radiation (LR) by means of the positioning device for generating the alignment auxiliary signal (AAS, AAS'), and
(y) removing the optical alignment auxiliary component from the illumination beam path of the EUV radiation.

13. Method according to Claim 12, wherein the optical alignment auxiliary component (AAC) comprises the alignment auxiliary mirror (AAM), **characterized by** the following step:
(v) reflecting a portion of the EUV radiation (LR) emerging from the secondary radiation source (SLS) in the direction of the alignment detector (AD) by means of the alignment auxiliary mirror in the working position.

14. Method according to any of Claims 11 to 13, wherein the optical alignment auxiliary component (AAC) comprises the alignment auxiliary radiation source (ALS), **characterized by** the following step:
(w) generating auxiliary radiation (ALR) by means of the alignment auxiliary radiation source, wherein the auxiliary radiation is directed in the direction of the alignment mirror element (AM), wherein in step (d) the alignment auxiliary signal (AAS') is generated from a portion of the auxiliary radiation reflected from the alignment mirror element.

15. Method according to Claim 14, wherein the illumination system (ILL) is assigned an alignment auxiliary detector (AAD) separate from the alignment detector (AD), **characterized by** the following step:
(x) receiving a portion of the auxiliary radiation (ALR)

reflected from the alignment mirror element (AM) by means of the alignment auxiliary detector, wherein in step (d) the alignment auxiliary signal (AAS') is generated from a portion of the auxiliary radiation received by the alignment auxiliary detector by means of the alignment auxiliary detector.

Patentansprüche

1. Beleuchtungssystem (ILL) für eine EUV-Projektionsbelichtungsanlage (WSC) zum Empfangen von EUV-Strahlung (LR) einer EUV-Strahlungsquelle (LS) und zum Formen von Beleuchtungsstrahlung (ILR) von mindestens einem Abschnitt der empfangenen EUV-Strahlung, wobei die Beleuchtungsstrahlung in ein Beleuchtungsfeld in einer Austrittsebene (ES) des Beleuchtungssystems während der Belichtungsoperation gelenkt wird,
wobei die EUV-Strahlungsquelle in einem von dem Beleuchtungssystem getrennten Quellenmodul (SM) angeordnet ist, wobei das Quellenmodul eine Sekundärstrahlungsquelle (SLS) an einer Quellenposition (SP) in einer Eintrittsebene (IS) des Beleuchtungssystems generiert, umfassend:

    ein Ausrichtungszustands-Bestimmungssystem (ADS) zum Bestimmen eines Ausrichtungszustands der Sekundärstrahlungsquelle bezüglich des Beleuchtungssystems, wobei das Ausrichtungszustands-Bestimmungssystem einen Ausrichtungsdetektor (AD) umfasst, der ausgebildet ist, einen Teil der aus der Sekundärstrahlungsquelle austretenden EUV-Strahlung zu empfangen und daraus ein den Ausrichtungszustand darstellendes Ausrichtungsdetektorsignal (AS) zu generieren, und
    ein Spiegelmodul (MM), das ein verwendetes Spiegelelement (UM) und ein Ausrichtungsspiegelelement (AM) umfasst, wobei während der Belichtungsoperation das verwendete Spiegelelement zur der Formung der auf das Beleuchtungsfeld auftreffenden Beleuchtungsstrahlung beiträgt, und das Ausrichtungsspiegelelement einen Teil der EUV-Strahlung der Sekundärstrahlungsquelle in der Richtung des Ausrichtungsdetektors reflektiert, **dadurch gekennzeichnet, dass**
    das Spiegelmodul (MM) als ein strukturell austauschbares Spiegelmodul verkörpert ist, und eine optische Ausrichtungshilfskomponente (AAC) dem Beleuchtungssystem (ILL) zugeordnet ist, wobei mit Hilfe der optischen Ausrichtungshilfskomponente ein Ausrichtungshilfssignal (AAS, AAS') generierbar ist, das ein Prüfen des Ausrichtungszustands der Sekundärstrahlungsquelle (SLS) oder eines Ausrichtungszustands eines Ausrichtungsspiegelelements (AM) nach einem Tausch des Spiegelmoduls gestattet.

2. Beleuchtungssystem (ILL) nach Anspruch 1, **dadurch gekennzeichnet, dass** dem Beleuchtungssystem eine Positionierungseinrichtung (PD, PD') zugeordnet ist, mit deren Hilfe die optische Ausrichtungshilfskomponente (AAC) außerhalb der Belichtungsoperation in einer Arbeitsposition in dem Beleuchtungsstrahlpfad (OP) der EUV-Strahlung (LR) positionierbar ist zum Generieren des Ausrichtungshilfssignals (AAS, AAS'), wobei bevorzugt die Positionierungseinrichtung (PD, PD', PD'') einen Faltungsmechanismus (FM, FM') umfasst.

3. Beleuchtungssystem (ILL) nach Anspruch 2, **dadurch gekennzeichnet, dass** die optische Ausrichtungshilfskomponente (AAC) einen Ausrichtungshilfsspiegel (AAM) umfasst, der ausgebildet ist, in der Arbeitsposition einen Teil der aus der Sekundärstrahlungsquelle (SLS) austretenden EUV-Strahlung (LR) in der Richtung des Ausrichtungsdetektors (AD) zu reflektieren, wobei bevorzugt dem Beleuchtungssystem (ILL) eine Positionierungseinrichtung (PD) zugeordnet ist, die einen Faltungsmechanismus (FM) umfasst, mit dessen Hilfe der mindestens eine Ausrichtungshilfsspiegel (AAM) zwischen einer verstauten Position außerhalb des Beleuchtungsstrahlpfads (OP) der EUV-Strahlung (LR) und einer Arbeitsposition in dem Beleuchtungsstrahlpfad (OP) zum Generieren des Ausrichtungshilfssignals (AAS) faltbar ist.

4. Beleuchtungssystem (ILL) nach Anspruch 3, **dadurch gekennzeichnet, dass** der mindestens eine Ausrichtungshilfsspiegel (AAM) in der Arbeitsposition in dem Beleuchtungsstrahlpfad optisch zwischen der Sekundärstrahlungsquelle (SLS) und dem Spiegelmodul derart angeordnet ist, dass er das mindestens eine Ausrichtungsspiegelelement abschatten kann.

5. Beleuchtungssystem (ILL) nach Anspruch 3 oder 4, **dadurch gekennzeichnet, dass** das Beleuchtungssystem (ILL) genau zwei Ausrichtungshilfsspiegel umfasst und/oder dass die Anzahl von Ausrichtungsspiegelelementen (AAM) der Anzahl von Freiheitsgraden des Ausrichtungszustands der Sekundärstrahlungsquelle (SLS) bezüglich des Beleuchtungssystems (ILL) entspricht.

6. Beleuchtungssystem (ILL) nach einem der Ansprüche 1 bis 5, **dadurch gekennzeichnet, dass** die optische Ausrichtungshilfskomponente (AAC) eine Ausrichtungshilfsstrahlungsquelle (ALS) umfasst, die ausgebildet ist, Hilfsstrahlung (ALR) zu generieren, die in der Richtung des Ausrichtungsspiegelelements (AM) gerichtet ist, wobei das Ausrichtungs-

hilfssignal (AAS') aus einem Teil der von dem Ausrichtungsspiegelelement reflektierten Hilfsstrahlung generiert wird, wobei bevorzugt die Positionierungseinrichtung (PD') ausgelegt ist, die Ausrichtungshilfsstrahlungsquelle (ALS) in der Arbeitsposition in oder nahe der Quellenposition (SP) der Sekundärstrahlungsquelle (SLS) zu positionieren und/oder eine Wellenlänge der Hilfsstrahlung (ALR) im UV-Bereich, VIS-Bereich oder im IR-Bereich ist.

7. Beleuchtungssystem (ILL) nach Anspruch 6, **dadurch gekennzeichnet, dass** dem Beleuchtungssystem ein von dem Ausrichtungsdetektor (AD) getrennter Ausrichtungshilfsdetektor (AAD) zugeordnet ist, wobei der Ausrichtungshilfsdetektor ausgebildet ist, einen Teil der von dem Ausrichtungsspiegelelement (AM) reflektierten Hilfsstrahlung (ALR) zu empfangen und daraus das Ausrichtungshilfssignal (AAS') zu generieren.

8. Beleuchtungssystem (ILL) nach einem der Ansprüche 1 bis 7, **dadurch gekennzeichnet, dass** das verwendete Spiegelelement (UM) direkt der Eintrittsebene (IS) in dem Beleuchtungsstrahlpfad (OP) folgt.

9. EUV-Projektionsbelichtungsanlage (WSC), umfassend:

- ein Beleuchtungssystem (ILL) nach einem der Ansprüche 1 bis 8,
- ein von dem Beleuchtungssystem getrenntes Quellenmodul (SM) mit einer EUV-Strahlungsquelle (LS) zum Generieren von EUV-Strahlung (LR), wobei das Quellenmodul eine Sekundärstrahlungsquelle (SLS) an einer Quellenposition (SP) in einer Eintrittsebene (IS) des Beleuchtungssystems generiert, und
- eine Ausrichtungseinheit (AU) signalverbunden mit dem Ausrichtungszustands-Bestimmungssystem (ADS) des Beleuchtungssystems zum Ausrichten der Sekundärstrahlungsquelle bezüglich des Beleuchtungssystems in Abhängigkeit von dem Ausrichtungsdetektorsignal (AS).

10. EUV-Projektionsbelichtungsanlage (WSC) nach Anspruch 9, **dadurch gekennzeichnet, dass** die Ausrichtungseinheit (AU) ausgelegt ist zum Ausrichten der Sekundärstrahlungsquelle (SLS) in Abhängigkeit von dem Ausrichtungshilfssignal (AAS), falls das Ausrichtungshilfssignal den Ausrichtungszustand der Sekundärstrahlungsquelle darstellt.

11. Verfahren zum Betreiben einer EUV-Projektionsbelichtungsanlage (WSC) nach Anspruch 9 oder 10, **gekennzeichnet durch** die folgenden Schritte:

(a) Abschalten der Sekundärstrahlungsquelle (SLS),
(b) Auswechseln des Spiegelmoduls (MM),
(c) Einschalten der Sekundärstrahlungsquelle,
(d) Generieren eines Ausrichtungshilfssignals (AAS, AAS') mit Hilfe der optischen Ausrichtungshilfskomponente (AAC),
(e) Prüfen des Ausrichtungszustands der Sekundärstrahlungsquelle oder eines Ausrichtungszustands eines Ausrichtungsspiegelelements (AM) nach einem Austausch des Spiegelmoduls mit Hilfe des generierten Ausrichtungshilfssignals, und
(f) Betreiben der EUV-Projektionsbelichtungsanlage unter Verwendung eines Ergebnisses der Prüfung.

12. Verfahren nach Anspruch 11, wobei die Positionierungseinrichtung (P) dem Beleuchtungssystem (ILL) zugeordnet ist, **gekennzeichnet durch** die folgenden Schritte:

(u) Positionieren der optischen Ausrichtungshilfskomponente (AAC) außerhalb der Belichtungsoperation in eine Arbeitsposition in dem Beleuchtungsstrahlpfad (OP) der EUV-Strahlung (LR) mit Hilfe der Positionierungseinrichtung zum Generieren des Ausrichtungshilfssignals (AAS, AAS'), und
(y) Entfernen der optischen Ausrichtungshilfskomponente aus dem Beleuchtungsstrahlpfad der EUV-Strahlung.

13. Verfahren nach Anspruch 12, wobei die optische Ausrichtungshilfskomponente (AAC) den Ausrichtungshilfsspiegel (AAM) umfasst, **gekennzeichnet durch** den folgenden Schritt:
(v) Reflektieren eines Teils der aus der Sekundärstrahlungsquelle (SLS) austretenden EUV-Strahlung (LR) in der Richtung des Ausrichtungsdetektors (AD) mit Hilfe des Ausrichtungshilfsspiegels in der Arbeitsposition.

14. Verfahren nach einem der Ansprüche 11 bis 13, wobei die optische Ausrichtungshilfskomponente (AAC) die Ausrichtungshilfsstrahlungsquelle (ALS) umfasst, **gekennzeichnet durch** den folgenden Schritt:
(w) Generieren von Hilfsstrahlung (ALR) mit Hilfe der Ausrichtungshilfsstrahlungsquelle, wobei die Hilfsstrahlung in der Richtung des Ausrichtungsspiegelelements (AM) gerichtet ist, wobei im Schritt (d) das Ausrichtungshilfssignal (AAS') aus einem Teil der von dem Ausrichtungsspiegelelement reflektierten Hilfsstrahlung generiert wird.

15. Verfahren nach Anspruch 14, wobei dem Beleuchtungssystem (ILL) ein von dem Ausrichtungsdetek-

tor (AD) getrennter Ausrichtungshilfsdetektor (AAD) zugeordnet ist, **gekennzeichnet durch** den folgenden Schritt:
(x) Empfangen eines Teils der von dem Ausrichtungsspiegelelement (AM) reflektierten Hilfsstrahlung (ALR) mit Hilfe des Ausrichtungshilfsdetektors, wobei in Schritt (d) das Ausrichtungshilfssignal (AAS') aus einem Teil der von dem Ausrichtungshilfsdetektor empfangenen Hilfsstrahlung mit Hilfe des Ausrichtungshilfsdetektors generiert wird.

Revendications

1. Système d'éclairage (ILL) pour un appareil d'exposition par projection d'EUV (WSC) pour recevoir un rayonnement EUV (LR) d'une source de rayonnement EUV (LS) et pour mettre en forme un rayonnement d'éclairage (ILR) à partir d'au moins une partie du rayonnement EUV reçu, dans lequel le rayonnement d'éclairage étant dirigé dans un champ d'éclairage dans un plan de sortie (ES) du système d'éclairage pendant une opération d'exposition,
dans lequel la source de rayonnement EUV est disposée dans un module de source (SM) séparé du système d'éclairage, ledit module de source générant une source de rayonnement secondaire (SLS) à une position de source (SP) dans un plan d'entrée (IS) du système d'éclairage, comprenant :

    un système de détermination d'état d'alignement (ADS) pour déterminer un état d'alignement de la source de rayonnement secondaire par rapport au système d'éclairage, dans lequel le système de détermination d'état d'alignement comprend un détecteur d'alignement (AD) configuré pour recevoir une partie du rayonnement EUV provenant de la source de rayonnement secondaire et pour générer, à partir de celle-ci, un signal de détecteur d'alignement (AS) représentatif de l'état d'alignement, et
    un module à miroirs (MM) comprenant un élément miroir utilisé (UM) et un élément miroir d'alignement (AM), dans lequel, pendant une opération d'exposition, l'élément miroir utilisé contribue à la mise en forme du rayonnement d'éclairage incident sur le champ d'éclairage, et l'élément miroir d'alignement réfléchit une partie du rayonnement EUV de la source de rayonnement secondaire dans la direction du détecteur d'alignement,
    caractérisé en ce que
    le module à miroirs (MM) est incorporé sous la forme d'un module à miroirs échangeable sur le plan structural, et
    un composant auxiliaire d'alignement optique (AAC) est attribué au système d'éclairage (ILL), dans lequel, à l'aide du composant auxiliaire d'alignement optique, un signal auxiliaire d'alignement (AAS, AAS') peut être généré, ce qui permet une vérification de l'état d'alignement de la source de rayonnement secondaire (SLS) ou d'un état d'alignement d'un élément miroir d'alignement (AM) après un échange du module à miroirs.

2. Système d'éclairage (ILL) selon la revendication 1, **caractérisé en ce que** le système d'éclairage est affecté d'un dispositif de positionnement (PD, PD'), au moyen duquel le composant auxiliaire d'alignement optique (AAC) en dehors d'une opération d'exposition peut être positionné en position de travail dans le trajet de faisceau d'éclairage (OP) du rayonnement EUV (LR) pour générer le signal auxiliaire d'alignement (AAS, AAS'), dans lequel, de préférence, le dispositif de positionnement (PD, PD', PD") comprend un mécanisme de pliage (FM, FM').

3. Système d'éclairage (ILL) selon la revendication 2, **caractérisé en ce que** le composant auxiliaire d'alignement optique (AAC) comprend un miroir auxiliaire d'alignement (AAM) configuré, en position de travail, pour réfléchir une partie du rayonnement EUV (LR) provenant de la source de rayonnement secondaire (SLS) dans la direction du détecteur d'alignement (AD), dans lequel, de préférence, le système d'éclairage (ILL) est affecté d'un dispositif de positionnement (PD) comprenant un mécanisme de pliage (FM), au moyen duquel le ou les miroirs auxiliaires d'alignement (AAM) peuvent être pliés entre une position de stockage en dehors du trajet de faisceau d'éclairage (OP) du rayonnement EUV (LR), et une position de travail dans le trajet de faisceau d'éclairage (OP) pour générer le signal auxiliaire d'alignement (AAS).

4. Système d'éclairage (ILL) selon la revendication 3, **caractérisé en ce que** le ou les miroirs auxiliaires d'alignement (AAM) en position de travail dans le trajet de faisceau d'éclairage sont agencés optiquement entre la source de rayonnement secondaire (SLS) et le module à miroirs de telle manière qu'ils puissent faire de l'ombre au ou aux éléments miroirs d'alignement.

5. Système d'éclairage (ILL) selon la revendication 3 ou 4, **caractérisé en ce que** le système d'éclairage (ILL) comprend exactement deux miroirs auxiliaires d'alignement et/ou **en ce que** le nombre d'éléments miroirs d'alignement (AAM) correspond au nombre de degrés de liberté de l'état d'alignement de la source de rayonnement secondaire (SLS) par rapport au système d'éclairage (ILL).

6. Système d'éclairage (ILL) selon l'une quelconque des revendications 1 à 5, **caractérisé en ce que** le

composant auxiliaire d'alignement optique (AAC) comprend une source de rayonnement auxiliaire d'alignement (ALS) configurée pour générer un rayonnement auxiliaire (ALR) qui est dirigé dans la direction de l'élément miroir d'alignement (AM), dans lequel le signal auxiliaire d'alignement (AAS') est généré à partir d'une partie du rayonnement auxiliaire réfléchi depuis l'élément miroir d'alignement, dans lequel, de préférence, le dispositif de positionnement (PD') est conçu pour positionner la source de rayonnement auxiliaire d'alignement (ALS) en position de travail à la position source (SP), ou proche de cette dernière, de la source de rayonnement secondaire (SLS) et/ou une longueur d'onde du rayonnement auxiliaire (ALR) se trouve dans la plage UV, la plage VIS ou dans la plage IR.

7. Système d'éclairage (ILL) selon la revendication 6, **caractérisé en ce que** le système d'éclairage est affecté d'un détecteur auxiliaire d'alignement (AAD) séparé du détecteur d'alignement (AD), ledit détecteur auxiliaire d'alignement étant configuré pour recevoir une partie du rayonnement auxiliaire (ALR) réfléchi depuis l'élément miroir d'alignement (AM) et pour générer le signal auxiliaire d'alignement (AAS') à partir de ce dernier.

8. Système d'éclairage (ILL) selon l'une quelconque des revendications 1 à 7, **caractérisé en ce que** l'élément miroir utilisé (UM) suit directement le plan d'entrée (IS) dans le trajet de faisceau d'éclairage (OP).

9. Appareil d'exposition par projection d'EUV (WSC) comprenant :

- un système d'éclairage (ILL) selon l'une quelconque des revendications 1 à 8,
- un module de source (SM) séparé du système d'éclairage ayant une source de rayonnement EUV (LS) pour générer un rayonnement EUV (LR), dans lequel le module de source génère une source de rayonnement secondaire (SLS) à une position de source (SP) dans un plan d'entrée (IS) du système d'éclairage, et
- une unité d'alignement (AU) connectée par un signal au système de détermination d'état d'alignement (ADS) du système d'éclairage pour aligner la source de rayonnement secondaire par rapport au système d'éclairage en fonction du signal de détecteur d'alignement (AS).

10. Appareil d'exposition par projection d'EUV (WSC) selon la revendication 9, **caractérisé en ce que** l'unité d'alignement (AU) est configurée pour aligner la source de rayonnement secondaire (SLS) en fonction du signal auxiliaire d'alignement (AAS) si le signal auxiliaire d'alignement est représentatif de l'état d'alignement de la source de rayonnement secondaire.

11. Procédé pour faire fonctionner un appareil d'exposition par projection d'EUV (WSC) selon la revendication 9 ou 10, **caractérisé par** les étapes suivantes consistant :

(a) à mettre hors tension la source de rayonnement secondaire (SLS),
(b) à échanger le module à miroirs (MM),
(c) à mettre sous tension la source de rayonnement secondaire,
(d) à générer un signal auxiliaire d'alignement (AAS, AAS') au moyen du composant auxiliaire d'alignement optique (AAC),
(e) à vérifier l'état d'alignement de la source de rayonnement secondaire ou un état d'alignement d'un élément miroir d'alignement (AM) après un échange du module à miroirs au moyen du signal auxiliaire d'alignement généré, et
(f) à faire fonctionner l'appareil d'exposition par projection d'EUV à l'aide d'un résultat de la vérification.

12. Procédé selon la revendication 11, dans lequel le dispositif de positionnement (P) est attribué au système d'éclairage (ILL), **caractérisé par** les étapes suivantes consistant :

(u) à positionner le composant auxiliaire d'alignement optique (AAC) en dehors d'une opération d'exposition en position de travail dans le trajet de faisceau d'éclairage (OP) du rayonnement EUV (LR) au moyen du dispositif de positionnement pour générer le signal auxiliaire d'alignement (AAS, AAS'), et
(y) à supprimer le composant auxiliaire d'alignement optique du trajet de faisceau d'éclairage du rayonnement EUV.

13. Procédé selon la revendication 12, dans lequel le composant auxiliaire d'alignement optique (AAC) comprend le miroir auxiliaire d'alignement (AAM), **caractérisé par** l'étape suivante consistant :
(v) à réfléchir une partie du rayonnement EUV (LR) provenant de la source de rayonnement secondaire (SLS) dans la direction du détecteur d'alignement (AD) au moyen du miroir auxiliaire d'alignement en position de travail.

14. Procédé selon l'une quelconque des revendications 11 à 13, dans lequel le composant auxiliaire d'alignement optique (AAC) comprend la source de rayonnement auxiliaire d'alignement (ALS), **caractérisé par** l'étape suivante consistant :
(w) à générer un rayonnement auxiliaire (ALR) au moyen de la source de rayonnement auxiliaire d'ali-

gnement, dans lequel le rayonnement auxiliaire est dirigé dans la direction de l'élément miroir d'alignement (AM), dans lequel, à l'étape (d), le signal auxiliaire d'alignement (AAS') est généré à partir d'une partie du rayonnement auxiliaire réfléchi depuis l'élément miroir d'alignement.

15. Procédé selon la revendication 14, dans lequel le système d'éclairage (ILL) est affecté d'un détecteur auxiliaire d'alignement (AAD) séparé du détecteur d'alignement (AD), **caractérisé par** l'étape suivante consistant :
(x) à recevoir une partie du rayonnement auxiliaire (ALR) réfléchi depuis l'élément miroir d'alignement (AM) au moyen du détecteur auxiliaire d'alignement, dans lequel, à l'étape (d), le signal auxiliaire d'alignement (AAS') est généré à partir d'une partie du rayonnement auxiliaire reçu par le détecteur auxiliaire d'alignement au moyen du détecteur auxiliaire d'alignement.

Fig.1

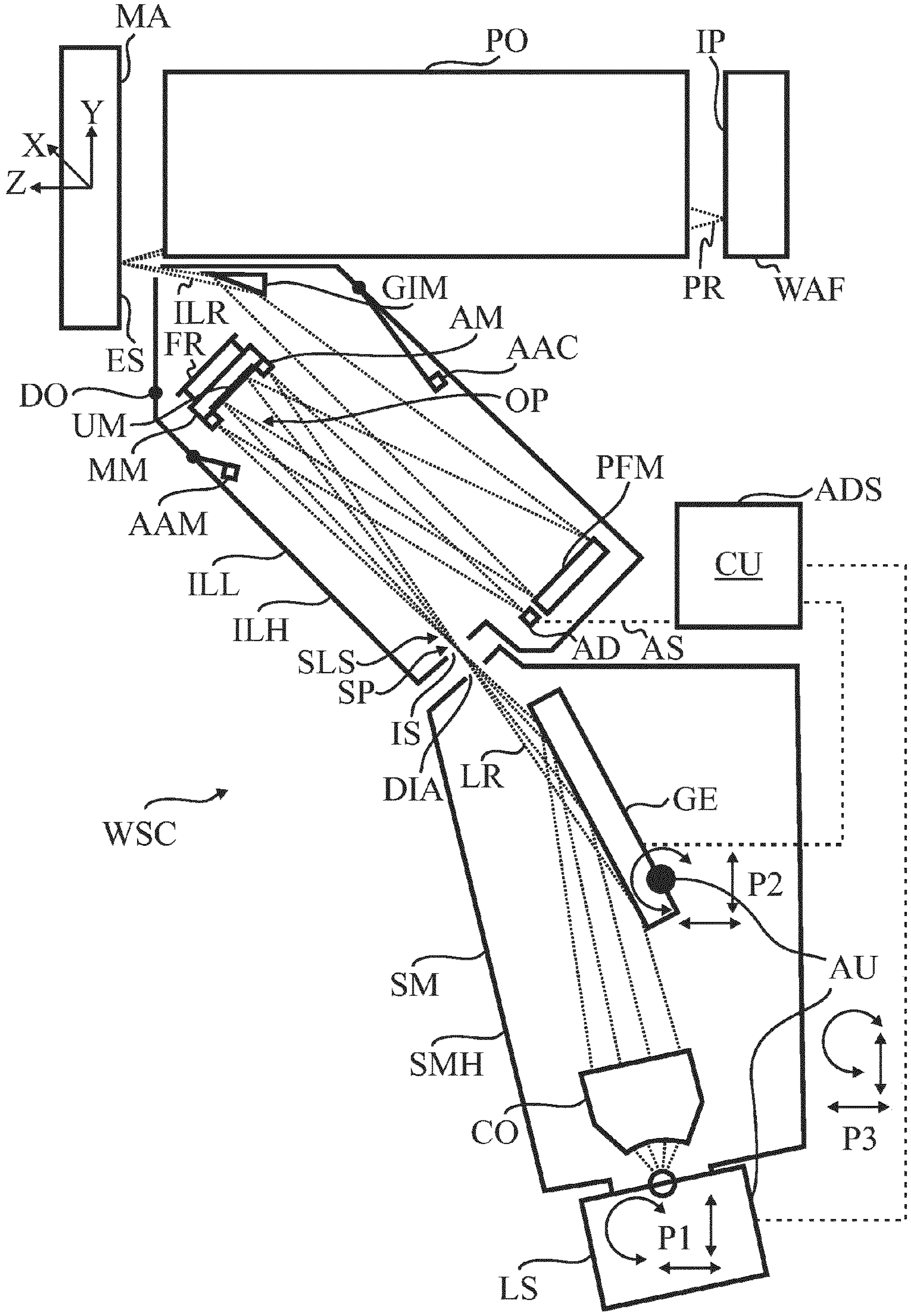
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Fig.2

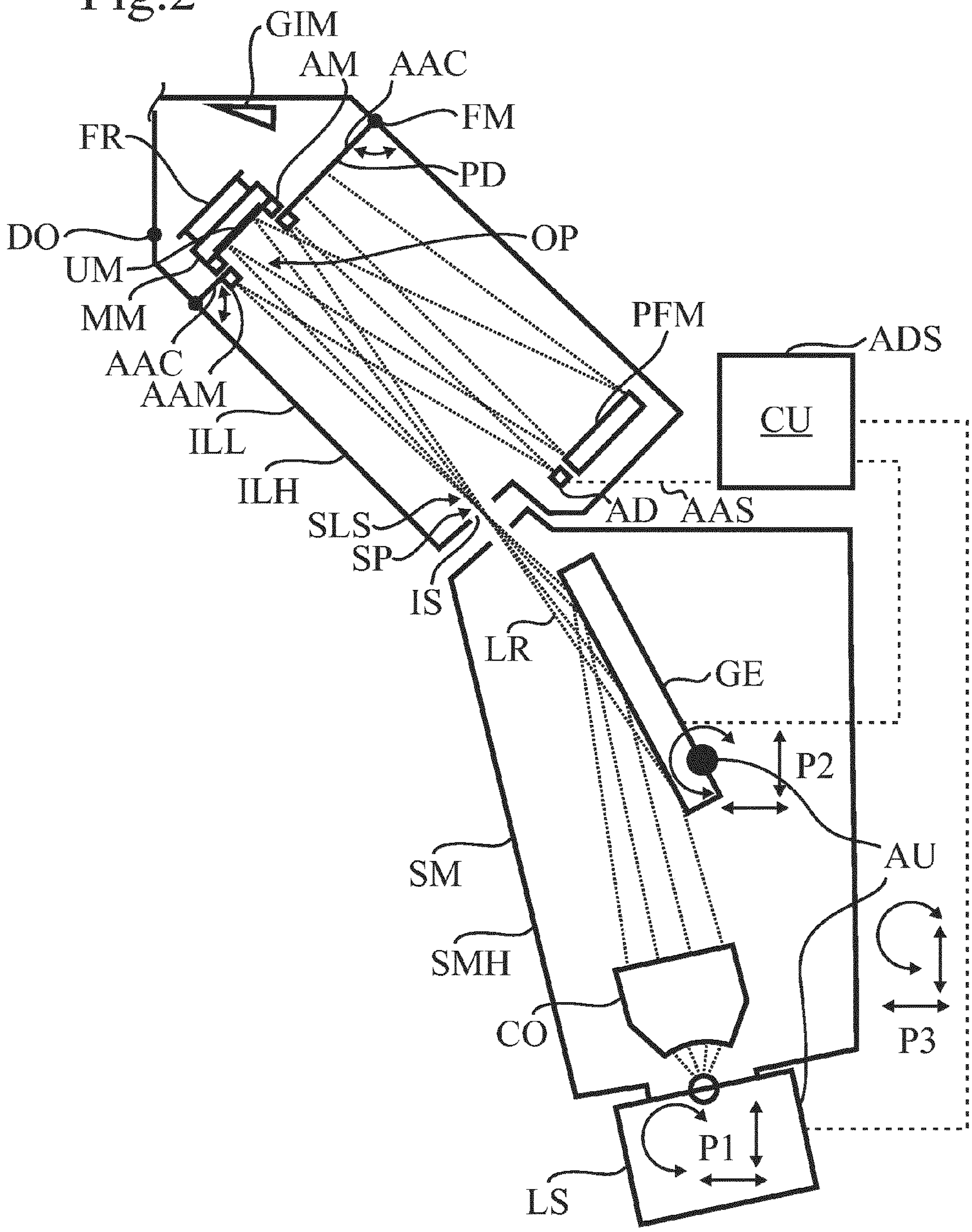
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Fig.3

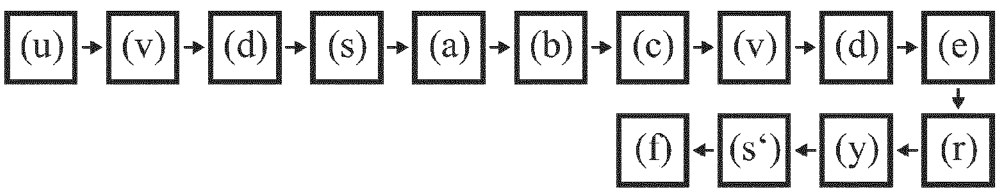
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Fig.4

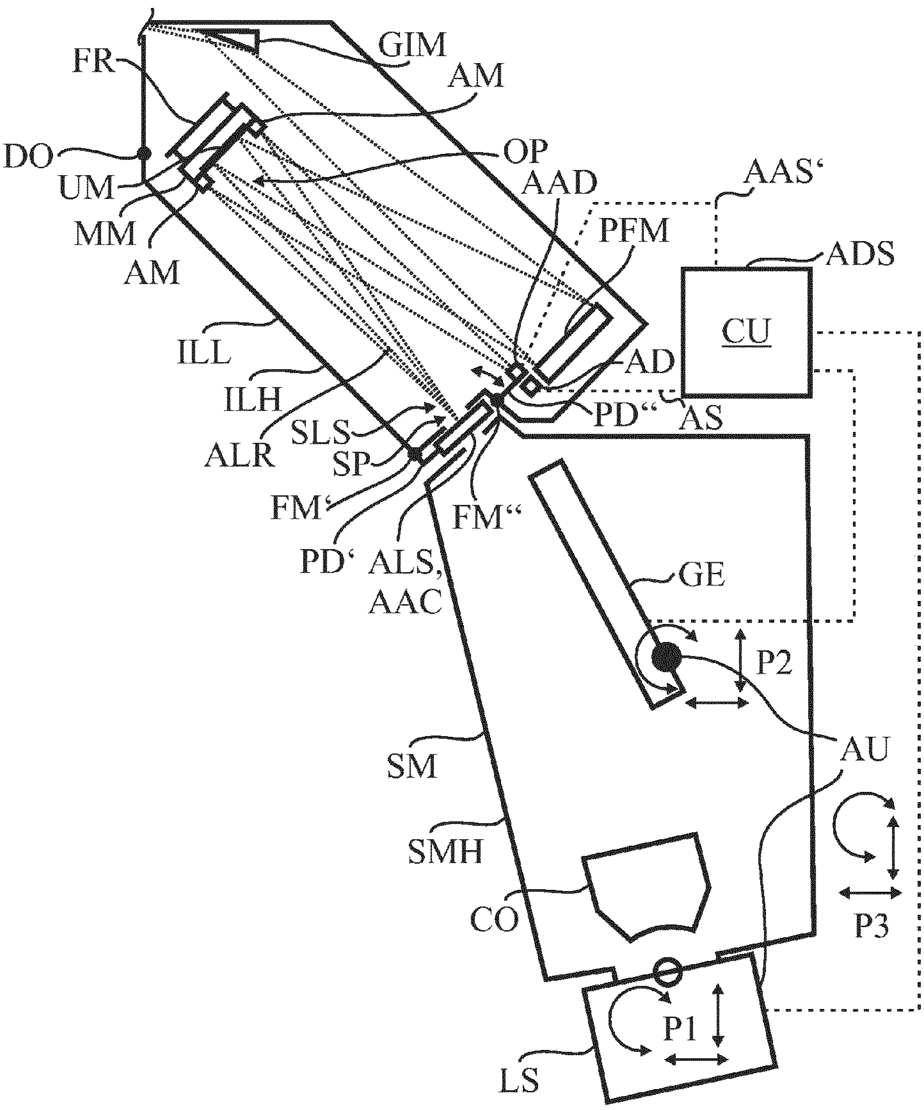
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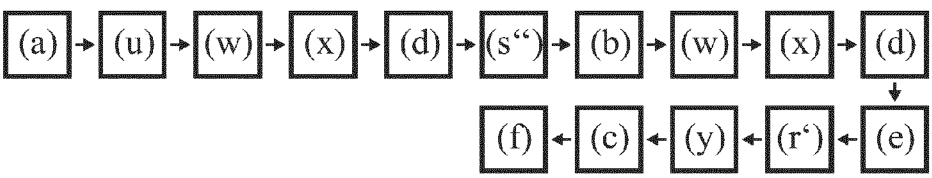
Fig.5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REFERENCES CITED IN THE DESCRIPTION

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